Structuring mobile and contextual learning

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ABSTRACT
Many attempts have been made to define the nature and focus of mobile learning. This study is based on a previous expert study that intends to structure the research problems that are underlying the domain of mobile and contextual learning. The previous study identified three core clusters of research problems in our domain. This paper analyses the research problems underpinning the previously identified clusters and identifies research topics within these clusters. This supports a more structured understanding of research problems that are specific to mobile and contextual learning and how these problems are related.

Author Keywords
Mobile learning, contextual learning, research questions, expert study

INTRODUCTION
Mobile learning is a research topic that connects the vibrant fields of mobile and ubiquitous technologies with education and learning. This topic strives for developing the educational paradigms and technologies for the mobile information societies. Several attempts have been made to define the nature and focus of mobile and contextual learning research (Sharples, 2006; Traxler, 2009). The perspectives taken are either techno-centric, consider the mobility of the learners, or rest upon the anytime/anywhere paradigm for content consumption (Winters, 2006; Taylor, 2006). Especially the techno-centric perspective is highly controversial because the underlying development of mobile technologies is continuously progressing. This makes the attempted definitions highly unstable (Traxler, 2009).

Traxler's (2009) suggestion to emphasize the role of education and learning of mobile learning motivated the present study. This has resulted in an empirical expert study that has focused on the structure of the underlying research problems of mobile learning (Börner, et al. 2010). Although the previous study identified three primary research clusters that are specific to mobile learning: "access to learning", "contextual learning", and "learning across contexts". However, that study did not analyse and compare their internal logic. This paper further analyses the results of this expert study in order to identify overarching research questions that are specific to mobile and contextual learning. Consequently, the present paper focuses on the research problems within the previously identified clusters. It analyses the relation and perceived value of research problems in relation to their clusters. This leads to insights to the kind of overarching problems that are tackled by mobile and contextual learning and relates them to concrete research challenges.

METHOD
In order to identify the underpinning research problems of mobile and contextual learning, the present study implements Trochim's (1989a, b) concept mapping approach. The underlying method has been applied in several studies (Stoyanov & Kirschner 2004; Wopereis, Kirschner, Paas, Stoyanov & Hendriks, 2005). It provides an approach to structured and participative conceptualization that identifies clusters of ideas and opinions empirically. The source data is collected from key stakeholders by brainstorming and categorizing ideas. The resulting data is then analysed via multidimensional scaling (Kruskal & Wish, 1978; Davison, 1983) and hierarchical cluster analysis (Anderberg, 1973; Everitt, 1980). The result is a set of visual maps representing the generated ideas and opinions as well as emerging clusters and thus important domain concepts. The method has three phases to collect the data that are described below.

The initial phase of the method has three objectives: defining an initial focus or trigger statement for stimulating the generation of ideas and opinions, selecting key dimensions for rating the generated statements, and selecting the participants. Derived from the first research question the following trigger statement was: "The educational problem that

mobile learning tries to solve is…". Based on the experiences of previous studies (Stoyanov & Kirschner 2004; Wopereis, Kirschner, Paas, Stoyanov & Hendriks, 2005), *importance* and *feasibility* were selected as respective key dimensions. These qualitative dimensions emphasize different aspects of the practices within the domain. During data inquiry the participants have to rate each statement on the two dimensions on a 5-point Likert-scale. For importance the value 1 means the statement described a less important educational problem that mobile learning is trying to solve and 5 means the statement described a highly important educational problem. Similarly, for feasibility the value 1 means solving the described educational problem through mobile learning is not feasible and 5 means that the problem could be solved through mobile learning.

The participants were selected from the member list of the International Association for Mobile Learning (IAMLearn, 2009). 32 international acknowledged experts have been invited to participate in the study. The invitees represented different stakeholder groups within the mobile learning domain, ranging from industry via research to educational practitioners. 20 of the invited experts accepted the invitation to participate in the study.

Given to the international distribution of the participants, the communication as well as the data collection has been conducted entirely online via e-mail. The data collection procedure has been conducted in the following two phases: (a) generating idea and opinion statements and (b) structuring the generated statements. Due to the characteristics of the method, the participants were actively involved in both steps of the data collection process. In order to collect as much information as possible from the participants while reducing the communication overhead, the categorization and the rating of the statements has been combined in the structuring phase.

In the second phase the participants were instructed to identify educational problems as short bullet point statements in relation to the trigger statement. The participants were free to generate as many statements as they liked. Furthermore, the participants were requested to describe exactly one educational problem per statement and if possible limit the generation process to 10 minutes.

In the third phase all participants were asked to structure the collected problem statements. The participants were contacted regardless of their participation in the previous phase. The structuring of the statements involved two independent steps: grouping the statements based on their perceived similarity in meaning and the rating of the statements. The participants were asked to perform this task within two weeks. 9 experts participated in the second phase, grouping and rating the statements that were previously generated.

For the first step the participants were asked to group the statements based on their similarity in meaning by copying the statements from one document containing all statements into a second document containing a prepared form with empty group containers. The participants were informed that they should place each statement only into a single group, while each group should contain statements that were similar in meaning. The instructions emphasized that the similarity must focus only on the content of the statement. If a statement in the participants' opinion was unrelated to the other statements or stood alone as a unique idea, they were asked to put this statement in its own group. Arbitrary groups such as "misc" or "junk" groups were explicitly forbidden. Again the experts were free to create as many groups as they liked, although it was suggested to them that 10 to 20 groups should work out well in most cases. After grouping the statements the experts were asked to rate each statement in the third document.

RESULTS

During the second phase, 11 experts generated 70 problem statements. For preparing the third phase the statements were restructured into grammatically correct sentences and simultaneously revised for spelling mistakes whenever this was necessary. Furthermore, statements that referred to several ideas were split so the resulting statements included only a single idea. Finally, all the statements were compared to eliminate obvious duplicates. The result of this data cleaning was a list of 82 unique statements. During the third phase, the experts created 111 groups in total with an average of 12 groups per expert.

The data analysis techniques described by Trochim (1989a) were used to map the problem statements, as well as to identify and to label the problem clusters. The clusters represent overarching domain concepts related to the educational problems addressed by mobile learning. Figure 1 shows the problem cluster map of the presented study. The distance between the points in Figure 1 indicates how often two statements were grouped together: the closer two points are, the more often the experts sorted them into the same groups. The following 7 problem clusters cover all 82 statements.

(1) Access to learning: The cluster covers 15 statements that mainly relate to the challenges of enabling learning in a mobile society. This includes educational problems that are related to flexible learning, including just-in-time learning, equal access to education and learning, as well as location-based learning. The cluster also covers remote learning and accessibility aspects.

(2) Limitations for learning: 9 statements belong to this cluster. The statements cover challenges related to organizational and educational problems of educational institutions that result from different perceptions of the knowledge society in general and mobile technologies specifically among educators and learners. This also includes the problems of using of mobile technologies in formal learning scenarios.

(3) Contextual learning: The cluster includes 18 statements that highlight the relation between learning and the context in which the learning takes place. The cluster covers individual aspects of situated learning, learning in context, and learning across contexts. Furthermore environmental aspects are included, such as making use of environmental affordances and a stronger interaction with the environment where the learning takes place.

(4) Collaboration: 5 statements are included in the cluster. The statements cover challenges that relate to collaboration, sharing learning resources, and problems related to social interaction, such as difficulties of building a community during learning.

(5) Personalization: The cluster includes 8 statements. The statements range from educational problems with self-directed learning to mass-customisation of learning and reflect the potential of mobile learning to support personal learning processes and engage learners.

(6) Learning across contexts: The 14 statements included in this cluster deal with problems related to current educational practices. The cluster is strongly related to the contextual learning cluster, but focuses more on how mobile learning can support the transition between contexts.

(7) Technology and technology adoption: The cluster covers 13 statements. These statements address challenges related to the technological characteristics of mobile devices and factors of their adoption, including cost effectiveness, usability, and user-acceptance.

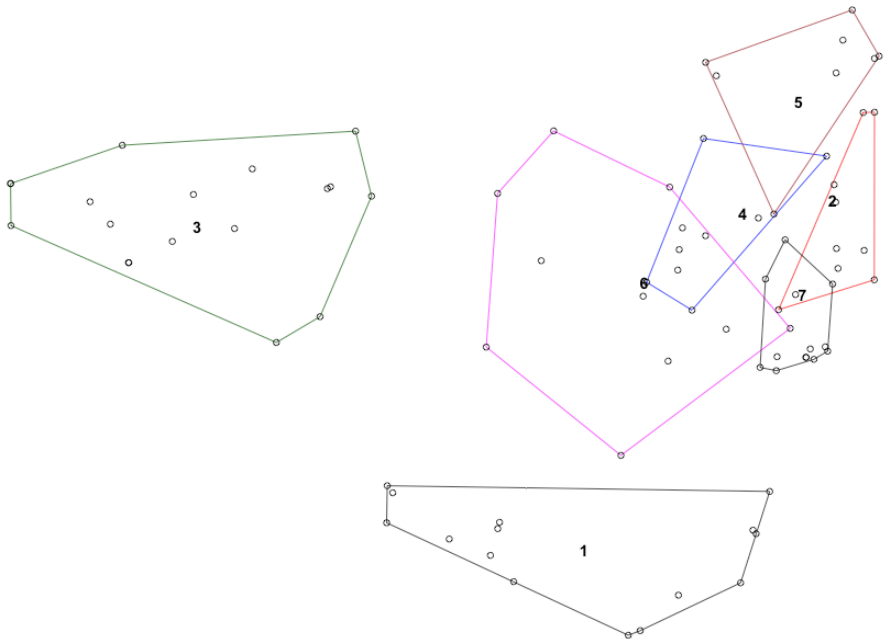

Figure 1 - Problem cluster map

The detailed analysis of the average rating of the problem statements indicates the experts' opinion about which statements refer to important and feasible educational problems related to mobile learning. Furthermore, this analysis allows estimating the relevance of the 7 problem clusters as domain concepts for mobile and contextual learning research.

Starting with the problem statement emphasis, a statement was considered as important or feasible if its mean rating was at least 3.5 on the 5-point Likert-scale rating. An average rating of 3.5 indicates that the experts rated the statement mostly as important or feasible. By taking both rating key dimensions into account the statements were mapped into four quadrants, which is presented in Figure 2.

The first quadrant contains those statements that are relevant on both dimensions, given a high average rating on importance and feasibility. These statements refer to the most relevant educational problems addressed by mobile learning. The second quadrant contains statements with a high average rating on importance but low average rating on feasibility. The statements in this quadrant can be considered to refer to important educational problems addressed by mobile and contextual learning, while sufficient solutions might go beyond the scope of this field. The third quadrant contains statements with low average ratings on both dimensions. These statements are considered to refer to educational problems that are not specifically related to mobile and contextual learning in the experts' opinion. The fourth quadrant contains statements with a high average rating on feasibility but low average rating on importance. The items in this quadrant refer to side problem to which the research field can offer solutions.

By comparing the results from the cluster analysis and the ratings, it shows that the majority of the statements in the first quadrant belong to the clusters "access to learning" (cluster 1) and "contextual learning" (cluster 3). The cluster "learning across contexts" (cluster 6) contains about the same amount of statements in the first and third quadrant, while the other

clusters primarily contain statements that are located in the third quadrant. Moreover, the mean rating of all statements in these three clusters is greater than 3.5 on at least one scale. Consequently, the clusters "access to learning", "contextual learning", and "learning across contexts" can be considered as the primary scope of research problems that are characteristic for mobile learning. The following analysis concentrates on the specific characteristics of these clusters.

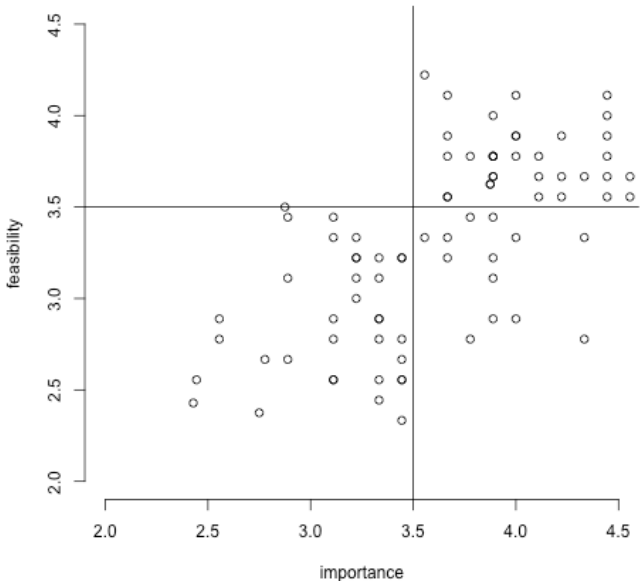

Figure 2 - Statement rating map including all statements

Cluster 1: Access to Learning

The access to learning cluster refers to a set of research problems that address the access to learning opportunities and educational resources. These research problems emphasize the "mobility of learners" (statement 25) as a central aspect for enabling learning. This specific area includes two themes. The first theme refers to challenges related to e-inclusion. The second theme in this cluster is best described by statement 17: "Access to learning resources and learning opportunities without restrictions of location, time and cumbersome equipment or facilities". A complete list of statements of this cluster is provided in Table 1.

Cluster		Mean	
	Statement	**Importance**	**Feasibility**
Cluster "Access to learning"		*4.03*	*3.59*
17	Access to learning resources and learning opportunities without the restrictions of location, time and cumbersome equipment or facilities.	4.44	4.00
59	Access to information when and where it is required, through 'just in time' browsing of relevant information, and information push to support learning in context.	4.44	3.89
41	Easing access to educational opportunities.	4.56	3.67
25	Mobility of the learner.	4.00	4.11
79	Including learners from rural areas.	4.22	3.89
61	Accessibility of information in relevant everyday life and work situations.	4.33	3.67
9	Learning at anytime.	3.98	4.00
80	Developing third world countries' education.	4.11	3.78
8	Learning from any location.	3.89	3.78
11	Just in time information for immediate application.	4.11	3.56
1	Limited access by some learners in remote locations.	3.67	3.89
51	Enable learners in classroom settings to have equal access to rich resources and computational tools to support curriculum learning.	3.89	3.22
78	Including learners with disabilities.	4.33	2.78
4	Nomads who move from one location to the next while learning.	3.22	3.22
45	Inequality of access to computers, learning resources and teachers.	3.33	2.44

Table 1: Statements and ratings of the cluster "access to learning"

The two themes are also visible in the problem cluster map for the related statements as shown in Figure 3. On the right-hand side of the cluster area are the statements about e-inclusion and on the left-hand side are those statements regarding flexible learning. In this cluster the mobility itself is the central aspect that influences the access to learning. Although the statements related to the two topics appear in different spatial areas in the cluster map, the cluster remains stable for

different "cuts" of the hierarchical cluster tree (for $2 < k < 10$). This indicates that the statements form a distinct class of research challenges rather then merging two sub-clusters.

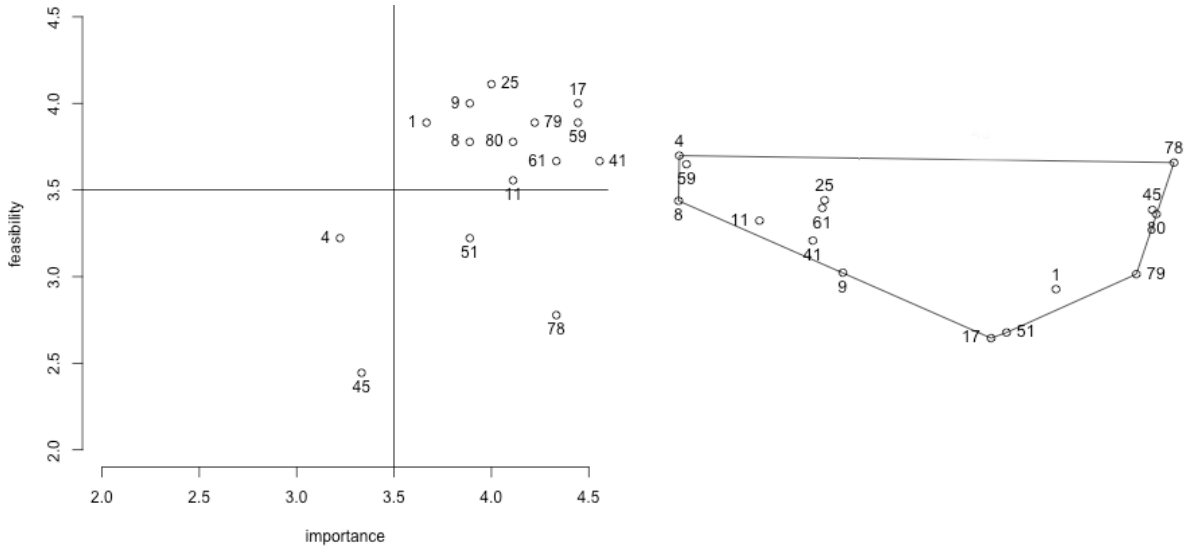

Figure 3: Access to learning: rating of statements (left) and statement relatedness (right)

Cluster 3: Contextual Learning

The contextual learning cluster integrates research challenges that emphasize the relation between learning and the setting in which it is situated. The cluster includes location-based learning problems (statement 39, 58, 29, 57, 55, 56, and 70), authentic learning (statement 3, 12, 16, 30, 33, and 50), and the relations between contexts (statement 53, 74, and 60). This cluster forms a distinct field of statements that appears isolated from other statements that were mentioned. Figure 4 shows the distribution of the statements on the cluster map as well as their average rating.

Cluster		Mean	
	Statement	Importance	Feasibility
Cluster "Contextual learning"		*3.92*	*3.60*
53	Connect learning across contexts, including between formal and informal settings.	4.44	3.78
16	Ability to discover and experiment in own context.	4.44	3.67
30	The provision of access to knowledge in the context in which it is applied.	4.56	3.56
33	Taking education out of classroom settings into meaningful settings.	4.00	3.89
39	Interacting with your environment to achieve new knowledge from it.	4.22	3.67
50	Under-utilization of potentially rich learning resources in heritage sites, art collections and all sorts of other interesting places.	3.56	4.22
73	Learning in context.	4.00	3.78
74	Learning across contexts.	4.22	3.56
58	Using technology to probe or to enrich understanding of the natural environment, and annotating the environment for the benefit of visitors.	3.67	4.11
29	The design of augmented contexts for development problem to enable collaborative problem solving where learners generate their own 'temporal context for development'.	3.89	3.78
12	Learners cannot learn in context.	3.88	3.63
57	Making use of affordances of locations to support learning.	3.88	3.63
55	Enable enquiry-based learning in novel locations, through novel locations, and about novel locations.	3.89	3.44
63	Contextualization of e-learning.	3.67	3.56
56	Making use of space and environment as a backdrop for engaged spatial learning.	3.67	3.22
70	The worthwhileness of location-based and contextual mobile learning.	3.56	3.33
60	Enable learning through distributed conversation across contexts.	3.78	2.78
3	Insufficient real life experience in the learning process.	3.22	3.22

Table 2: Statements and ratings of the cluster "contextual learning"

The statements in this cluster have in common that they refer to abstract research problems. The statements "learning in context" (statement 73), "contextualization of e-learning" (statement 63), or "Connect learning across contexts, including

between formal and informal settings" (statement 53) are typical for this cluster. A complete overview of the statements is provided in Table 2.

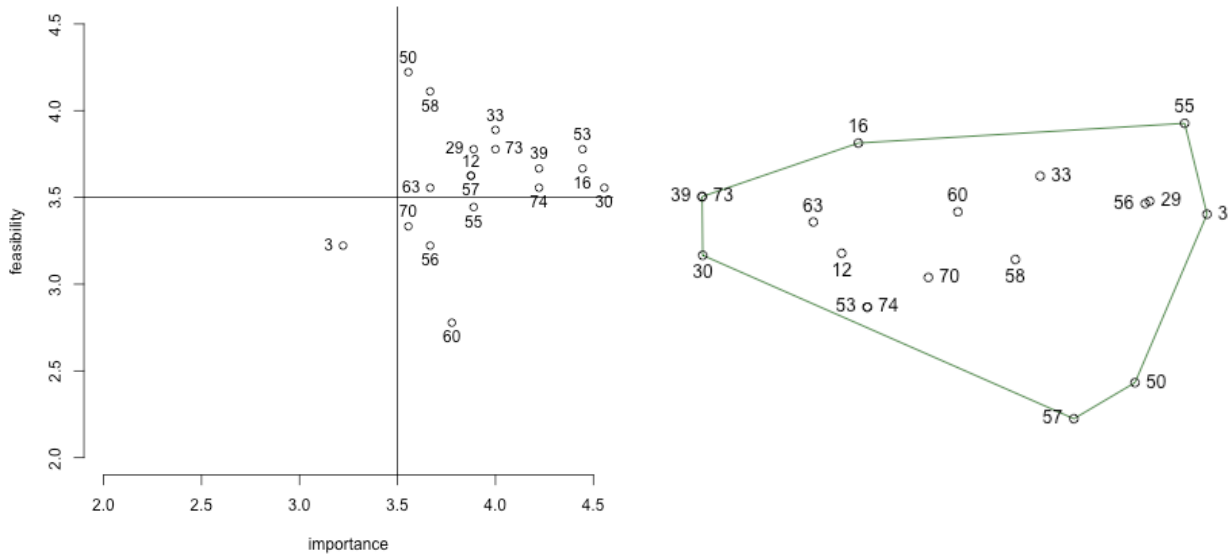

Figure 4: Contextual learning: rating of statements (left) and statement relatedness (right)

Cluster 6: Learning across contexts

Cluster 6 combines statements that focus on the transition between and the integration of contexts, particular with respect to the connection of classroom-based with informal learning experiences. Within this overarching scope of the cluster three topics are present that are also reflected by the highest rated statements. The first topic addresses the arrangement and orchestration of learning opportunities (statement 62, 37, 52, and 18), the second topic covers the transition between (spatial) contexts (statement 28 and 54), and the third topic refers to the participation and collaboration across contexts (statement 20, 49, and 52). A detailed overview over this cluster's statements and their ratings is provided in Table 3.

Most statements in this cluster highlight the activity facet of mobility as a relevant factor for learning. Furthermore, the entire cluster appears to be more related to educational applications and practice of mobile learning, because it contains more concrete research challenges than the other two clusters. This is also reflected by the closer relation of this cluster to the technical aspects of mobile learning (cluster 7), collaboration (cluster 4), and the limitation of learning (cluster 2).

The problem cluster map indicates a close relation to the "collaboration" cluster (cluster 4) as the statements 10 and 19 of cluster 4 appear deep in the area of the "learning across contexts" cluster (Figure 5). Statement 10 relates loosely to the participation topic without explicitly referring to specific contexts. Statement 19 is related to the arrangement of learning opportunities, but emphasizes context independent aspects.

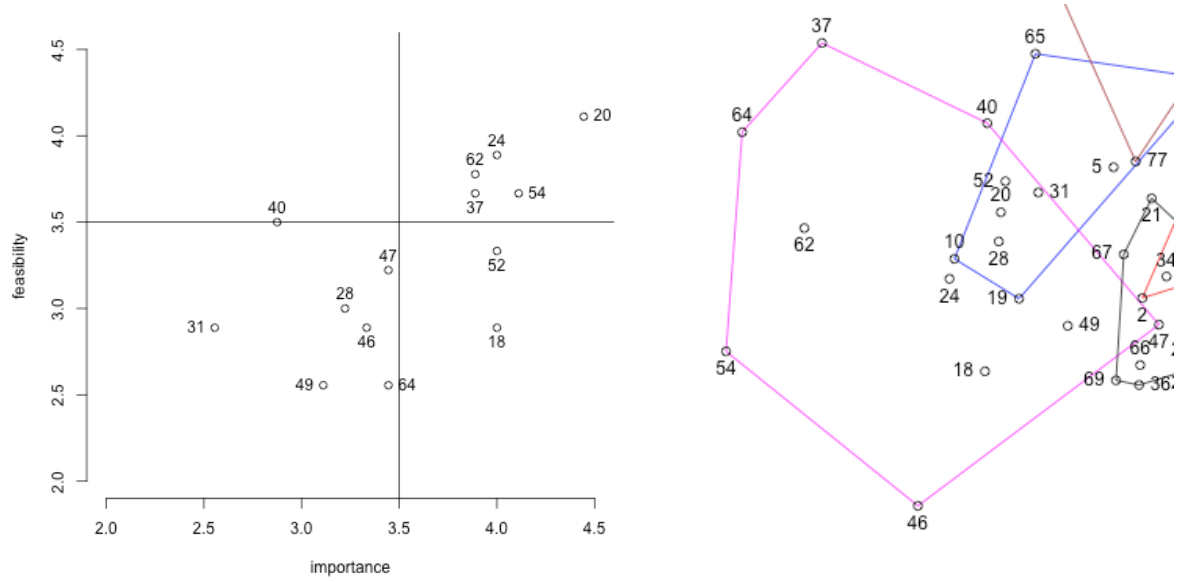

Figure 5: Learning across contexts: rating of statements (left) and statement relatedness (right)

Cluster / Statement	Mean Importance	Mean Feasibility
Cluster "Learning across contexts"	*W3s*	*3.60*
20 Actively participate in learning activities outside of formal educational settings and facilities.	4.44	4.11
24 Flexibility for the learner.	4.00	3.89
54 Maintaining continuity of learning across settings, such as between classrooms and museums on school field trips.	4.11	3.67
62 Documenting real time experiences of learners.	3.89	3.78
37 Design suitable activities for the mobile learners.	3.89	3.67
52 Orchestrate new forms of classroom pedagogy that require coordination of individual, small group and whole class activity.	4.00	3.33
18 Provision of opportunities to contribute to the development/production of learning resources and course content without the restrictions of location, time and cumbersome equipment or facilities.	4.00	2.89
47 Blinkered, old-fashioned views about education stopping when working lives begin.	3.44	3.22
40 Anything is a potential learning scenario.	2.88	3.50
28 Outside in, inside out problem, where cultural practices involving new digital media can be brought into formal learning institution, get enhanced inside the institution and in turn feedback into the digital world at large.	3.22	3.00
46 Pressured, busy, fragmented, mobile lives leaving little quality time for conventional, place-and-time-dependent education.	3.33	2.89
64 Transfer of training.	3.44	2.56
49 Gaps (time lags) between traditionally scheduled learning sessions, limiting achievement, teamwork and collaboration.	3.11	2.56
31 Refreshing the image and practice of institutional e-learning.	2.56	2.89

Table 3: Statements and ratings of the cluster "learning across contexts"

DISCUSSION

The analysis of the experts' statements revealed 7 research problem clusters to which research on mobile and contextual learning contributes. 3 clusters appear specific to the field, because the experts who participated in the study rated the statements covered by these clusters primarily as highly relevant on the two rating dimensions "importance" and "feasibility" identified these clusters. For the clusters "access to learning" and "contextual learning" the mean scores of both dimensions were above 3.5. For the cluster "learning across contexts" the mean score on the importance scale was above the threshold. The other 4 clusters had mean scores below 3.5 for both rating scales.

The analysis of the statements in the clusters indicated that each cluster relates to one overarching challenge for learning. Related to these research challenges recurring topics of the statements within the clusters were identified. These topics allow research to focus on specific research questions within the scope of a challenge. Table 4 lists the research challenges and the related topics.

The distribution of the statements within each cluster indicates that the related topics are specific to the cluster and do not represent sub clusters. Only for cluster 1 ("access to learning") the statements related to the included topics appear in different spatial areas in the cluster map. However, this cluster remains stable for different "cuts" of the hierarchical cluster tree.

Learner mobility (Cluster "Access to learning")
E-inclusion
Flexible learning
Influence of context on learning (Cluster "Contextual learning")
Location-based learning
Authentic learning
Relations between contexts
Transitions between contexts (Cluster "Learning across contexts")
Arrangement and orchestration of learning opportunities
Transition between contexts
Participation and collaboration across contexts

Table 4: Research challenges and related topics

When comparing the statements of the clusters a remarkable difference was found for the highly statements of cluster 3 "Contextual learning" and cluster 6 "Learning across contexts". The highly rated statements of cluster 3 are relatively

vague (Table 2), while the highly rated statements in cluster 6 refer to more concrete educational and learning problems than similar statements in other clusters (Table 3). This suggests that the topics in cluster 3 are not as well understood as for other clusters and require more fundamental research. Similarly, the topics of cluster 6 appear to be well enough understood for addressing applied research problems.

CONCLUSIONS

This paper analysed the results from an expert study for structuring the domain of mobile and contextual learning. This study has identified 7 clusters of research areas that are relevant to this domain, of which 3 clusters appear to be specific to mobile and contextual learning. Within these primary research clusters 8 research topics were identified. Together with the clusters, the topics can get used to structure the core research challenges of mobile and contextual learning.

The identified clusters provide a coherent perspective on mobile and contextual learning challenges beyond the scope of technology applications. Among the most relevant clusters, most of the prominent problem statements were relatively vague. This suggests that this field of technology-enhanced learning is still emerging and many important facets require development for defining more concrete perspectives on the identified research challenges.

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